CLAIMS

We claim:

[c1] 1. A computer-based integrated analysis system for determining performance characteristics associated with a turbine, the turbine including at least a compressor, a combustor and an expander, the system comprising:

a performance module capable of determining at least a power output associated with the turbine, the performance module including a performance server component and a performance analysis component, wherein the performance server component facilitates data exchange between the performance module and at least one other module, and wherein the performance analysis component contains at least one equation useable in connection with turbine performance analysis;

an aerodynamic module capable of determining at least an operating pressure associated with the expander, the aerodynamic module including an aerodynamic server component and an aerodynamic analysis component, wherein the aerodynamic server component facilitates data exchange between the aerodynamic module and at least one other module, and wherein the aerodynamic analysis component contains at least one equation useable in connection with expander flow analysis; and

a data management component that automatically directs an exchange of data between the performance module and the aerodynamic module.

[c2] 2. The integrated analysis system of claim 1 further comprising a secondary flow module capable of determining at least a portion of a flow through the compressor that bypasses the combustor and passes to the expander, the secondary flow module including a secondary flow server component and a secondary flow analysis component, wherein the secondary flow server component facilitates data exchange between the secondary flow module and at least one other module, and wherein the secondary flow analysis component contains at least one equation useable in connection with secondary flow analysis, wherein the data management component automatically directs an exchange of data between the performance module, the aerodynamic module and the secondary flow module.

[c3] 3. The integrated analysis system of claim 2 further comprising a heat transfer module capable of determining at least a temperature of a component of the expander, the heat transfer module including a heat transfer server component and a heat transfer analysis component, wherein the heat transfer server component facilitates data exchange between the heat transfer module and at least one other module, and wherein the heat transfer analysis component contains at least one equation useable in connection with heat transfer analysis, wherein the data management component automatically directs an exchange of data between the performance module, the aerodynamic module, the secondary flow module and the heat transfer module.

[c4] 4. The integrated analysis system of claim 3 further comprising a component life module capable of determining at least a life span of a component of the expander, the component life module including a component life server component and a component life analysis component, wherein the component life server component facilitates data exchange between the

component life module and at least one other module, and wherein the component life analysis component contains at least one equation useable in connection with a finite element stress analysis, wherein the data management component automatically directs an exchange of data between the performance module, the aerodynamic module, the secondary flow module, the heat transfer module and the component life module.

[c5] 5. The integrated analysis system of claim 4 further comprising a bottoming cycle module capable of determining at least a power output of a bottoming cycle, the bottoming cycle module including a bottoming cycle server component and a bottoming cycle analysis component, wherein the bottoming cycle server component facilitates data exchange between the bottoming cycle module and at least one other module, and wherein the bottoming cycle analysis component contains at least one equation useable in connection with bottoming cycle performance analysis, wherein the data management component automatically directs an exchange of data between the performance module, the aerodynamic module, the secondary flow module, the heat transfer module, the component life module and the bottoming cycle module.

[c6] 6. The integrated analysis system of claim 5 further comprising a heat balance module capable of determining at least a heat rate for a gas turbine, the heat balance module including a heat balance server component and a heat balance analysis component, wherein the heat balance server component facilitates data exchange between the heat balance module and at least one other module, and wherein the heat balance analysis component contains at least one equation useable in connection with gas turbine performance analysis, wherein the data management component automatically directs an exchange of data between the performance module, the aerodynamic

module, the secondary flow module, the heat transfer module, the component life module, the bottoming cycle module and the heat balance module.

[c7] 7. The integrated analysis system of claim 6 further comprising a cost module capable of determining at least a cost associated with operating the turbine, the cost module including a cost server component and a cost analysis component, wherein the cost server component facilitates data exchange between the cost module and at least one other module, and wherein the cost analysis component contains at least one equation useable in connection with gas turbine economic analysis, wherein the data management component automatically directs an exchange of data between the performance module, the aerodynamic module, the secondary flow module, the heat transfer module, the component life module, the bottoming cycle module, the heat balance module and the cost module.

[c8] 8. A method in a computer system for providing information related to a gas turbine having an expander, the method comprising:

providing a performance module capable of determining at least a power output associated with the turbine, the performance module including a performance server component and a performance analysis component, wherein the performance server component facilitates data exchange between the performance module and at least one other module, and wherein the performance analysis component contains at least one equation useable in connection with turbine performance analysis;

providing an aerodynamic module capable of determining at least an operating pressure associated with the expander, the aerodynamic module including an aerodynamic server component and an

aerodynamic analysis component, wherein the aerodynamic server component facilitates data exchange between the aerodynamic module and at least one other module, and wherein the aerodynamic analysis component contains at least one equation useable in connection with expander flow analysis;

operating the performance module to determine a first value for a first property variable associated with the expander;

transferring the first value from the performance module to the aerodynamic module;

operating the aerodynamic module to determine a second value for a second property variable associated with the expander based on the first value received from the performance module;

transferring the second value from the aerodynamic module to the performance module; and

operating the performance module to determine a third value for the first property variable based on the second value received from the aerodynamic module.

[c9] 9. The method of claim 8 further comprising:

determining an error percentage between the third and first values of the first property variable; and

when the error percentage is greater than a specified error percentage,

transferring the third value from the performance module to the aerodynamic module;

operating the aerodynamic module to determine a fourth value for the second property variable based on the third value received from the performance module;

transferring the fourth value from the aerodynamic module to the performance module; and

operating the performance module to determine a fifth value for the first property variable based on the fourth value received from the aerodynamic module.

[c10] 10. The method of claim 8 wherein the expander includes at least a first stage, the first stage having a first nozzle assembly defining a forward plane and a first bucket assembly defining an aft plane, and wherein the first property variable is a pressure proximal to the forward plane of the nozzle assembly and the second property variable is a pressure proximal to the aft plane of the bucket assembly.

[c11] 11. The method of claim 8 wherein the expander includes at least a first stage, the first stage having a first nozzle assembly defining a forward plane and a first bucket assembly defining an aft plane, and wherein the first property variable is a pressure proximal to the forward plane of the nozzle assembly and the second property variable is an efficiency associated with the first stage.

[c12] 12. The method of claim 8 wherein the expander includes at least a first stage, the first stage having a first nozzle assembly defining a forward plane and a first bucket assembly defining an aft plane, and wherein the first property variable is a pressure proximal to the forward plane of the nozzle assembly and the second property variable is a power associated with the first stage.

[c13] 13. The method of claim 8 wherein the gas turbine further includes a compressor and a combustor, the method further comprising:

providing a secondary flow module capable of determining at least a portion of a flow through the compressor that bypasses the combustor and passes to the expander, the secondary flow module including a secondary flow server component and a secondary flow analysis component, wherein the secondary flow server component facilitates data exchange between the secondary flow module and at least one other module, and wherein the secondary flow analysis component contains at least one equation useable in connection with secondary flow analysis;

transferring the second value from the aerodynamic module and the third value from the performance module to the secondary flow module;

operating the secondary flow module to determine a fourth value for a third property variable associated with the expander based on the second value received from the aerodynamic module and the third value received from the performance module;

transferring the fourth value from the secondary flow module to the performance module; and

operating the performance module to determine a fifth value for the first property variable based on the fourth value received from the secondary flow module.

[c14] 14. The method of claim 13 wherein the expander includes at least a first stage, the first stage having a first nozzle assembly defining a forward plane and a first bucket assembly defining an aft plane, and wherein the first property variable is a pressure proximal to the forward plane of the nozzle assembly, the second property variable is a pressure proximal to the aft plane of

the bucket assembly and the third property variable is a flow distribution associated with the first stage.

[c15] 15. The method of claim 13 further comprising:

determining the error percentage between the fifth and third values of the first property variable; and

when the error percentage is greater than a specified error percentage,

transferring the fifth value from the performance module to the aerodynamic module;

operating the aerodynamic module to determine a sixth value for the second property variable based on the fifth value received from the performance module;

transferring the sixth value from the aerodynamic module to the performance module; and

operating the performance module to determine a seventh value for the first property variable based on the sixth value received from the aerodynamic module.

[c16] 16. A method in a computer system for providing information related to performance of a power plant, the power plant having a turbine that includes an expander, the method comprising:

receiving a request for a user interface display page from a user computer;

in response to the received request, providing the requested user interface display page to the user computer, the requested user interface display page being configured to receive information related to an operating condition or configuration of the turbine;

receiving the information related to an operating condition or configuration of the turbine from the user computer;

in response to the received information,

operating a first analysis module to generate a first value for a first property variable related to a flow through the expander;

transferring the first value from the first analysis module to a second analysis module;

operating the second analysis module to determine a second value for a second property variable related to the flow through the expander based on the first value received from the first analysis module;

transferring the second value from the second analysis module to the first analysis module; and

operating the first analysis module to determine a third value for the first property variable based on the second value received from the second analysis module.

[c17] 17. The method of claim 16 wherein the first property variable is a pressure and the second property variable is an expander stage power or an expander stage efficiency.

[c18] 18. The method of claim 16 wherein the requested user interface display page is configured to receive a turbine type and further includes one or more display fields for presenting at least one of the first, second or third values.

[c19] 19. The method of claim 16 wherein the first analysis module is a performance module and the second analysis module is an aerodynamic module.

[c20] 20. The method of claim 16 further comprising:

determining an error percentage between the third and first values of the first property variable; and

when the error percentage is greater than a specified error percentage,

transferring the third value from the first analysis module to the second analysis module;

operating the second analysis module to determine a fourth value for the second property variable based on the third value received from the first analysis module;

transferring the fourth value from the second analysis module to the first analysis module; and

operating the first analysis module to determine a fifth value for the first property variable based on the fourth value received from the second analysis module.

[c21] 21. The method of claim 16 further comprising:

transferring the second value from the second analysis module and the third value from the first analysis module to a third analysis module;

operating the third analysis module to determine a fourth value for a third property variable related to the flow through the expander based on the second value received from the second analysis module and the third value received from the first analysis module; and

transferring the fourth value from the third analysis module to the first analysis module; and

operating the first analysis module to determine a fifth value for the first property variable based on the fourth value received from the third analysis module.

[c22] 22. The method of claim 21 wherein:

the first analysis module is a performance module;

the second analysis module is an aerodynamic module;

the third analysis module is a secondary flow module;

the first property variable is an expander pressure;

the second property variable is an expander interstage temperature or pressure; and

the third property value is an expander stage flow distribution.

[c23] 23. A computer system for providing information related to a turbine having an expander, the computer system comprising:

first analysis means for determining at least a power output associated with the turbine;

second analysis means for determining at least an operating pressure associated with the expander;

means for operating the first analysis means to determine a first value for a first property variable associated with the expander;

means for transferring the first value from the first analysis means to the second analysis means;

means for operating the second analysis means to determine a second value for a second property variable associated with the expander based on the first value received from the first analysis means;

means for transferring the second value from the second analysis means to the first analysis means; and

means for operating the first analysis means to determine a third value for the first property variable based on the second value received from the second analysis means.

[c24] 24. The computer system of claim 23 further comprising:

means for determining an error percentage between the third and first values of the first property variable; and

when the error percentage is greater than a specified error percentage,

means for transferring the third value from the first analysis means to the second analysis means;

means for operating the second analysis means to determine a fourth value for the second property variable based on the third value received from the first analysis means;

means for transferring the fourth value from the second analysis means to the first analysis means; and

means for operating the first analysis means to determine a fifth value for the first property variable based on the fourth value received from the second analysis means.

[c25] 25. The computer system of claim 23 wherein the turbine further includes a compressor and a combustor, the system further comprising:

third analysis means for determining at least a portion of a flow through the compressor that bypasses the combustor and passes to the expander;

means for transferring the second value from the second analysis means and the third value from the first analysis means to the third analysis means;

means for operating the third analysis means to determine a fourth value for a third property variable associated with the expander based on the second value received from the second analysis means and the third value received from the first analysis means;

means for transferring the fourth value from the third analysis means to the first analysis means; and

means for operating the first analysis means to determine a fifth value for the first property variable based on the fourth value received from the third analysis means.

[c26] 26. The method of claim 25 wherein the turbine is a gas turbine and the expander includes at least a first stage, the first stage having a first nozzle assembly defining a forward plane and a first bucket assembly defining an aft plane, and wherein the first property variable is a pressure proximal to the forward plane of the nozzle assembly, the second property variable is a pressure proximal to the aft plane of the bucket assembly and the third property variable is a flow distribution associated with the first stage.

[c27] 27. A computer-readable medium containing a display page for receiving information related to a configuration of a turbine and presenting information related to performance parameters of the turbine, the display page comprising:

a user input portion having one or more fields configured to receive information defining the turbine configuration for evaluation;

an output summary portion having one or more fields for presenting performance parameters for the turbine as defined by the information received in the input portion; and

a convergence summary portion having a property variable field, a first value field, and a second value field, wherein the property variable field identifies a property variable associated with a flow through the turbine, the first value field presents a value corresponding to a first determination of the property variable, and the second value field presents a value corresponding to a second determination of the property variable.

[c28] 28. The computer-readable medium of claim 27 wherein:

the first value field of the convergence summary portion presents a value determined by iteration between a first and second analysis module, and

the second value field of the convergence summary portion presents a value determined by iteration between the first and second analysis modules and a third analysis module.

[c29] 29. The computer-readable medium of claim 27 wherein:

the first value field of the convergence summary portion presents a value determined by iteration between a performance analysis module and an aerodynamic analysis module, and

the second value field of the convergence summary portion presents a value determined by iteration between the performance analysis module, the aerodynamic analysis module, and a secondary flow analysis module.

[c30] 30. The computer-readable medium of claim 27 wherein the display page further comprises tab bar, the tab bar including one or more user selectable tabs, wherein selection of one of the user-selectable tabs causes a spreadsheet to be displayed containing data related to the performance parameters of the turbine.

[c31] 31. The computer-readable medium of claim 27 wherein the user input portion further includes an analysis option portion, the analysis option portion including one or more user-selectable analysis options, the one or more user selectable analysis options being related to the first and second values presented in the convergence summary portion.

[c32] 32. The computer-readable medium of claim 31 wherein the one or more user-selectable analysis options include a first analysis option corresponding to determining the property variable by iteration between a first and second analysis module, and a second analysis option corresponding to determining the property variable by iteration between the first and second analysis modules and a third analysis module.

[c33] 33. A computer-readable medium whose contents cause a computer system to provide information related to performance of a power plant, the power plant having a turbine that includes an expander, the information being provided by a method comprising:

receiving a request for a user interface display page from a user computer;

in response to the received request, providing the requested user interface display page to the user computer, the requested user

interface display page being configured to receive information related to an operating condition or configuration of the turbine;

receiving the information related to an operating condition or configuration of the turbine from the user computer;

in response to the received information,

operating a first analysis module to generate a first value for a first property variable related to a flow through the expander;

transferring the first value from the first analysis module to a second analysis module;

operating the second analysis module to determine a second value for a second property variable related to the flow through the expander based on the first value received from the first analysis module;

transferring the second value from the second analysis module to the first analysis module; and

operating the first analysis module to determine a third value for the first property variable based on the second value received from the second analysis module.

[c34] 34. The computer-readable medium of claim 33 wherein the first property variable is a pressure and the second property variable is an expander stage power or an expander stage efficiency.

[c35] 35. The computer-readable medium of claim 33 wherein the requested user interface display page is configured to receive a turbine type and further includes one or more display fields for presenting at least one of the first, second or third values.

[c36] 36. The computer-readable medium of claim 33 wherein the first analysis module is a performance module and the second analysis module is an aerodynamic module.

[c37] 37. The computer-readable medium of claim 33 wherein the method further comprises:

determining an error percentage between the third and first values of the first property variable; and

when the error percentage is greater than a specified error percentage,

transferring the third value from the first analysis module to the second analysis module;

operating the second analysis module to determine a fourth value for the second property variable based on the third value received from the first analysis module;

transferring the fourth value from the second analysis module to the first analysis module; and

operating the first analysis module to determine a fifth value for the first property variable based on the fourth value received from the second analysis module.